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AUTHOR Dai, Meme F.; Capie, William
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ABSTRACT

The objective of this study was to assess the misconceptions held by preservice teachers about essential concepts of the moon related to information taught in elementary schools in Taiwan and to develop multiple-choice test items to identify the misconceptions about the moon. Additionally, this study considered relationships of gender, religion, and science major to misconceptions about the moon. The lack of preparation preservice teachers receive in astronomy is identified and ways of enhancing the earth science teacher training curriculum are suggested. Instrument development, identification of misconceptions, results, effective instructional models, and teaching strategies are discussed. (KR)

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MISCONCEPTIONS ABOUT THE MOON HELD BY PRESERVICE TEACHERS IN TAIWAN

Meme F. Dai

Department of Science Education
University of Georgia
Athens, Georgia 30602

William Capie

Department of Science Education
University of Georgia
Athens, Georgia 30602

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MISCONCEPTIONS ABOUT THE MOON HELD BY PRESERVICE TEACHERS IN TAIWAN

Meme F. Dai William Capie

Department of Science Education
University of Georgia
Athens, Gerogia 30602

Introduction

Misconceptions have been extensively investigated. For example, misconceptions in the area of biology, Smith and Anderson (1984) found that fifth graders held the preconception that plants get their "food" from the soil. Treagust and Haslam (1986) developed an instrument to assess students' misconceptions about photosynthesis and respiration in plants in grades 8-12. Goldberg and McDermott (1986) conducted interviews with college students to asses their difficulties in understanding image formation by a plane mirror. Stead and Osborne's investigation (1981) showed that children' preconceptions of friction included that friction increases with the speed of sliding and that objects can resist sliding because they are stuck. Gabel, Samuel and Hunn (1987) conducted a study with students, and indicated that the students thought when a liquid changes to a gas the atoms enlarge rather than become farther apart. Nussbaum (1976) interviewed second-grade children to assess their concepts of the earth. The children believe that the ground limits space "below" the earth and sky limits space "above" the earth. Much research has focused on misconceptions of preservice teachers (Stepans,

Dyche & Beiswenger, 1988; Crawley & Arditzoglou, 1988) who held science misconceptions.

In Taiwan, science educators have begun to study the physical science misconceptions held by secondary students (Hwang & Hwang, 1987; Kuo, 1989). Yet, no investigation was found that focused on misconceptions of astronomy held by elementary preservice teachers. A desired outcome of elementary science education in Taiwan is that students learn accurate science information and acquire science concepts that help them adequately understand their environment. Elementary school children construct concepts based largely on what the teacher teaches. However, most nations, including Taiwan, face a shortage of qualified science teachers (Finson & Enochs, 1988) with strong science background (Lawrenz, 1986). In Taiwan, elementary teachers are particularly weak in astronomy because their only exposure to the subject is a small unit taught as part of their only Earth Science course. Further this earth science course is only one aspect of their four year teacher training curriculum.

Blosser (1987) argued that the elementary school science teaching is in need of improvement. Teachers can not be expected to teach scientific concept that they do not understand (Lederman & Zeidler, 1987). Preservice teachers soon become inservice teachers passing on to their elementary pupils their misconceptions about the moon (Dai, 1990). Research has shown that students' misconceptions often interfere with their science

learning (Eaton, Anderson & Smith, 1984). Consequently, teachers who have misconceptions themselves are not able to recognize the misconceptions held by their students. If preservice teacher training programs are to prepare preservice teachers who can identify and challenge thier students' misconceptions then preservice teachers' own misconceptions must be identified and challenged.

The moon is an important part of Chinese culture (Bredon & Mitrophanow, 1966). A traditional Chinese family worships Heaven on the first and fifteenth day of every lunar month, these days honor the new moon and full moon phases, respectively. Chinese are interested in appreciation of the moon at night because they have read much literature related to the moon. Lunar phases have become the basis for the calendar that influences the daily life of Chinese people. For instance, farmers' market activities are scheduled according to the lunar calendar and most cultural festivals fall on the days of the full moon.

Chinese acquire concepts about the moon from daily experiences and in school. As a result, the moon is the most familiar heavenly object to most Chinese. However, people take the phases of the moon for granted. While one might expect a sound knowledge of astronomy among Chinese people, in fact, many retain notions that are not compatible with scientifically held concepts. This conflict between culturally based moon and scientific concepts poses a problem for elementary school children. The Taiwan national standard curriculum for elementary

pupils requires that they learn many concepts about the moon, such as the lunar phase, the time of moonrise, and the moon's position relative to the time. Systematic identify misconception related to the moon is needed.

Multiple-choice tests have been recommended for group diagnose of misconceptions, especially, with large class size and regular instruction. (Amir, Frankle, & Tamir, 1989; Clement, Brown & Zeitsman, 1989; Hsiung, 1989; Tamir, 1989; & Treagust & Haslam, 1986). In Taiwan the range of class size is from 45 to 55 students for all grades. Pencil-and-paper multiple choice tests can be readily used and easily scored by teachers in their classrooms. These tests also provide the benefits of an objective item, short response time. Multiple-choice tests enable the inclusion of specific misconceptions and provides detailed information about the frequency distribution of these misconceptions within a certain group of students.

The objective of this study was to assess the misconceptions held by preservice teachers about essential concepts of the moon required for teaching elementary science in Taiwan and to develop multiple-choice test items which identify the misconceptions about the moon. Additionally, this study considers the difference of gender, religion and science major affecting misconception about the moon. Finally, this paper addresses the lack of preparation of preservice teachers receive in astronomy and suggests ways of enhancing the earth science teacher training curriculum.

Instrument Development

The process of developing the test, called Identification of Misconceptions about the Moon Test (IMMT), started by identifying areas of understanding about the moon. This was based on the researcher's teaching experience and interviews with inservice and preservice teachers. A pilot study involved administering the tests, performing data analysis and making revisions.

A Chinese version of IMMT which combined open-ended questions with multiple-choice items was distributed to an intact class of thirty-eight non-science education-major students who were enrolled in Taipei Municipal Teacher College. The open ended questions were added to collect variations in justification or explanation about their moon concepts. Examinees were allowed to ask questions regarding test questions and answers during the examination process so that the investigator could confirm that examinees understood the questions. Interviews were also held to provide additional information on the preservice teacher's misconceptions about the moon. The explanations and justifications of their answers were then transformed into plausible distractors for the test pilot. The first draft, an English version, was composed of 45 multiple-choice items which had three distractors and one correct answer.

Since the phenomena of heavenly objects are difficult to describe verbally, most of the items are pictorial to minimize reading demand. The first Chinese version draft was administered to 181 preservice teachers from three Taiwan teacher colleges.

The data analysis includes item analysis, difficulties, and item discriminations. The distractors which were chosen by a small percentage of sample were deleted. Those items which were extremely difficult or easy were replaced or deleted. The version draft was revised and new items were added according to experts' comments. The second version consisted of 33 items and was administered to 41 preservice teachers at Taipei Municipal Teacher College. Again the results of the data analysis were then used to revise the test items.

The final revised draft consisted of 25 multiple-choice items. The conceptions assessed in this test are required for teaching elementary school children. These concepts are: the cause of lunar phases, the prediction of lunar phases, the position of the moon associated with the time of moonrise, determination of the moon's position at certain time, conceptioning lunar phase from a bird's-eye view, and the moon's rotation and revolution. In addition, concepts about lunar eclipse, lunar gravity and the moon's affect on the seas were also included in the test.

The content validity was accomplished by submitting the drafts to a panel of experts consisting of three professors of earth science and one science educator. The science educator served both as content validator and as Chinese-English translation reviewer. A panel of experts was asked to identify possible item construction errors. Face validity was reviewed by the group of experts also. The interview findings, which closely

matched the test distractors, served as a construct validity. The reliability of internal consistency is .65 (KR-20). Item difficulties ranged from .28 to .72. Item discrimination ranged from .05 to .54.

Identification of Misconceptions

The final draft was administered during Fall, 1989 to a sample of 174 preservice teachers from three Taiwan teacher colleges which train the elementary school teachers. The preservice teachers were freshmen, sophomores or seniors; 86 were male, 88 female; 29 were from non-religious background while 145 were from religious background; and 26 were science education majors and 148 non-science education majors. All subjects were subgrouped according to gender, religious background (those whose family regularly worship Heaven and those who did not), and science or non-science education-major. Intact classes were taken for the assessment. Students were allowed as much time as needed; most took about 30 minutes.

The responses of the test were analyzed. Descriptive statistics for each item were calculated. Frequency of total group as well as subgroups were comparatively analyzed. T-tests were computed to determine significant differences between male and female preservice teachers, religious and non-religious backgrounds, and science education-major and non-science education-majors.

Findings

The wide range of responses across distractors for most questions indicates that the majority of preservice teachers possess misconceptions about the moon. Table 1 contains the IMMT mean scores and S.D. for total group, gender, religion and education major subgroups. The maximum and minimum scores are also showed in the table. Table 2 is a display of the 25 IMMT items grouped by concept and providing the percentage of preservice teachers who responded to each distractor. The discussion of these preservice teachers' misconceptions is organized first by total group and subgroup, and within groups by concept.

Total Group

Misconceptions about Lunar Phases:

The preservice teachers were unable to accurately predict either the day of a lunar month from a drawing of a lunar phase or the lunar phase from a specified lunar day. When completing a representive diagram (see Figure 1), they thought that the area the moon that faces the earth is the only portion that is bright (rather than the half facing the sun). They also thought that the entire surface of moon is lit when there is a full moon, that it is entirely dark when there is a new moon, and it was half dark and half bright when there is a quarter moon.

Table 1: IMMT Means Scores, Standard deviation, and Maximum and Minimum Scores for Total, Gender, Religion and Major Groups

group		N	M	S. D.	Maximum	Minimum
total		174	11.1	3.97	23	3
gender	F	86	10.96	3.72	21	4
	M	88	11.24	4.22	23	3
religion	No	29	10.65	3.50	19	3
	Yes	145	11.94	4.06	23	4
major	SE	26	9.12	3.1	16	4
	NSE	148	11.44	4.00	23	3

Table 2

Percentage of Preservice Teachers Responding to Each Distractor

concept	item no. item description	a	b	c	d
lunar phase:					
	1. determine lunar day from a drawing phase	19.5	35.6	1.70	43.1
	2. predict lunar phase from certain lunar day	26.4	15.5	38.5	19.5
	3. discover correct diagram representing how sun light reaches the moon	14.4	56.9	17.8	10.9

4. reason for answering question 3	8.6	52.3	24.7	14.4
position of the moon:				
5. predict the position of the moon 3 hrs later	28.7	46.0	5.7	19.5
6. predict the position on next day at same time	39.1	28.2	13.2	19.5
7. determine the position of the day before at same time	31.0	36.2	4.6	28.2
8. predict the position on the same day of next month	28.2	40.2	20.1	11.5
9. reason for answering questions 5,6,7 & 8	24.7	24.8	17.4	28.2
bird's-eye view:				
10. determine the lunar phase when observe a model	37.9	24.1	28.2	9.8
13. formation of bird's - eye view	13.8	37.4	20.7	28.2
16. spaceman's view of phases	17.3	46.0	20.7	16.1
reasons for lunar & earth phases:				
11. reasons for lunar phases	24.7	19.5	29.9	25.9
14. determine earth phase from moon's view	12.6	5.2	72.4	9.8
15. reasons for earth phase	14.4	19.0	55.2	11.5
time of moonrise:				
12. determine the time of moonrise from diagram	16.1	37.9	32.8	13.2
23. predict the time of moonrise next day	25.9	5.2	63.2	5.7
24. reasons for the moon appears in the west in the morning	50.0	7.5	27.6	14.9
moon's rotation and revolution:				
17. determine if the moon turn around	19.5	28.2	9.8	42.5
18. how long 'one day' on the moon	23.6	10.3	15.3	50.6
19. reasons for answering question 18	15.0	49.4	28.7	6.9
20. day eclipse occurs	25.3	51.7	20.7	2.3

21. how the moon rotates & revolves	40.8	10.3	35.6	13.2
affect of gravity:				
22. what happens if an apple dropped on the moon	17.2	30.5	9.2	43.1
25. determine the sea tide at specific location	29.3	18.4	16.1	36.2

* Bold figures are correct distractors.

Misconceptions about the Moon's Position in relation to Specified Times:

During interviews, preservice teachers were confronted with the question, "If the moon appears in the west in the morning, where will it be three hours later?" Most teachers were confused and unable to answer the question. There were similar responses on the IMMT. They could not accurately predict the positions of the moon at the same time on the next day or the day before. That is, they did not accurately predict the time of moonrise on the next day as being later and the precious day as being earlier. These teachers believed that the moon rises higher on the same day of next lunar month rather than the earth's position changing each month.

Misconceptions about the Causes of Lunar and Earth Phases:

Preservice teachers believed that lunar phases were caused when the earth's shadow covered the moon. Some of them believed that the lunar phases are due to changes in the amount of light reflected from the moon. Some of the preservice teachers indicated that earth's phases occur because the size of the area of the earth reflecting sunlight changed.

Misconceptions about Bird's-eye View:

When asked, the preservice teachers could not choose a picture of either the moon's or earth's phase from a spaceman's view. (see Figure 2) Neither could they flip perspective when asked to conceptualize a bird's-eye view of a sun-earth-moon model. (see Figure 3)

Misconceptions about Moon's Rotation and Revolutions:

Many of these preservice teachers thought that the duration between two consecutive mornings on the moon was 24 hours. Some of them thought that the moon takes half a day (12 hours) to turn her back so that she is facing to the earth while others thought the movement would take two weeks. They expected to see a space ship that landed on the far side of the moon after a certain period of time because the moon would turn around. Some of preservice teachers believed that when the moon rotates, it spins just like the earth spins (see Figure 4). Some of them thought that a lunar eclipse occured on the new moon night instead of full moon night.

Figure 1 A presentational diagram of how the moon reflects the light.

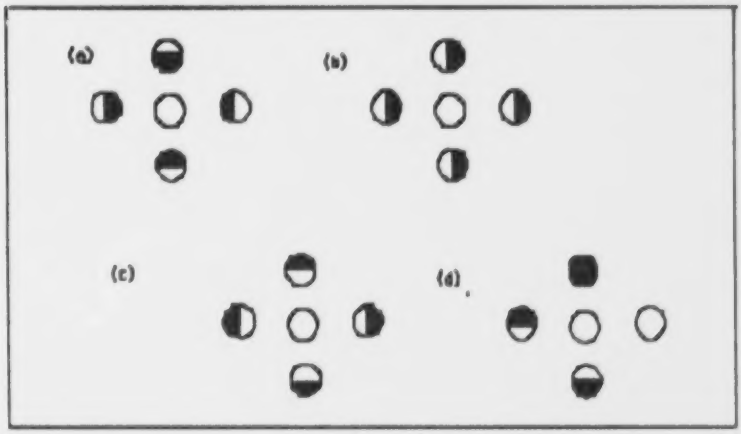


Figure 2 The spaceman is looking the earth and the moon.

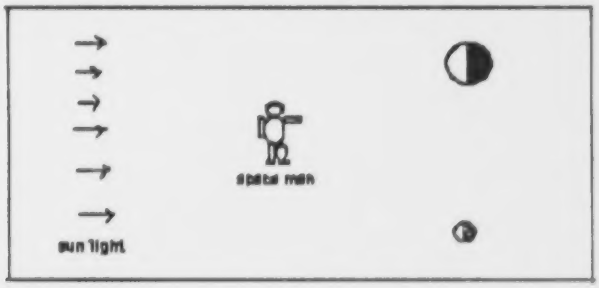
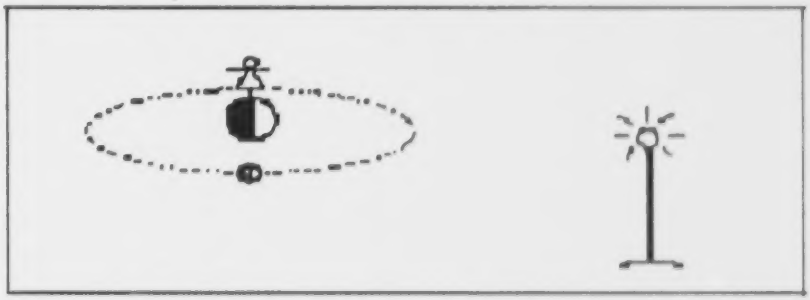
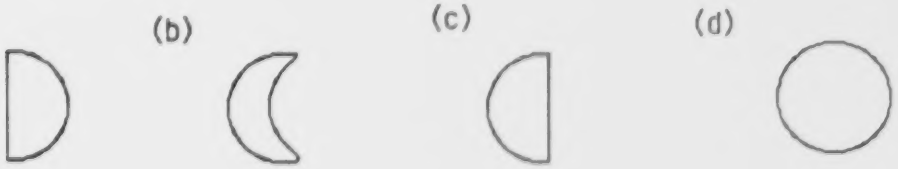


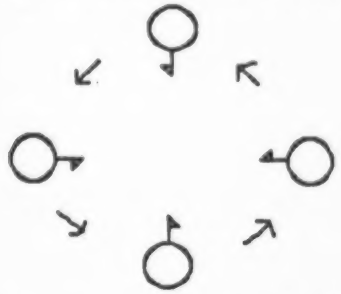
Figure 3 A model of the sun-earth-moon



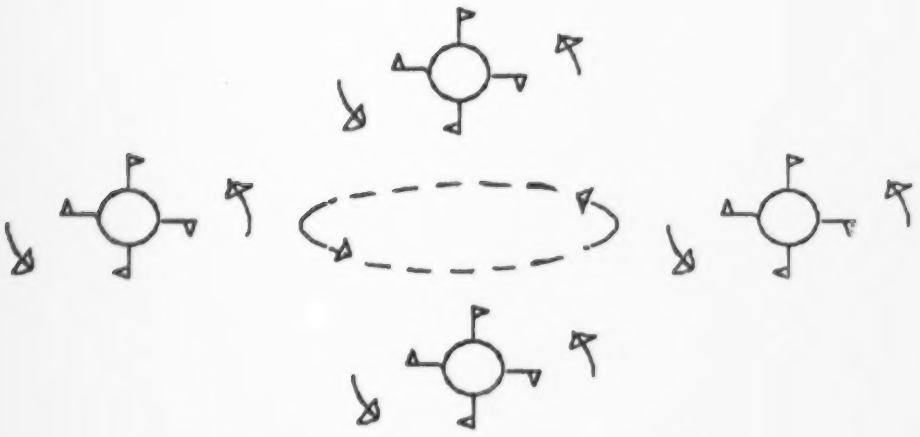
(a) (b) (c) (d)



Fiagure 4 Revolution and Rotation



The moon revolves around the earth while rotates.



The earth revolves around the sun while spins.

Figure 5 Shape Difference between lunar clipse and phase

lunar clipse lunar phase

Misconceptions about the Affects of Gravity:

Given questions about the affect of gravity, some preservice teachers believed that an apple would float in the air if it were dropped on the moon because of the moon's lower gravitational force. Some teachers indicated that when there is a high tide along a certain longitude in the Northern hemisphere, there will be low tide in the Southern hemisphere along that same longitude. Some of the preservice teachers also believed that when a high tide occurred at longitude 120 degrees East, there must be another high tide occurring at longitude 120 degrees West.

Subgroup

The IMMT data were also analyzed to determine if there were significant differences in the misconceptions held by male and female preservice teachers , students with religious (R) and non-religious (NR) backgrounds, and science education (SE) and non-science education (NSE) majors preservice teachers.

Gender:

There was no significant difference between the mean scores of male and female preservice teachers at the .05 level of significance. The results across the gender groups showed that both male and female preservice teachers have similar patterns of misconceptions about the moon. Table 3 shows an example of the similarity of percentage in exampled items. What misconceptions they held were similar to the findings of total group.

Table 3
Percentage of Female And Male Preservice Teachers Responsed in Items 1, 7, 13, and 24.

no. of item	gender	distractor 1	2	3	4
1	female	20.9	36.0	1.2	41.9
	male	18.2	35.2	2.3	44.3
7	female	30.2	38.4	5.8	25.6
	male	31.8	34.1	3.4	30.7
13	female	16.3	33.7	25.6	24.4
	male	15.9	39.8	27.3	17.0
24	female	54.7	4.7	27.9	12.8
	male	45.5	10.2	27.3	17.0

Religions:

The non-religious-backgrounds had too samll sample size to include the result of t-test. However, based on the samples available in this study, the percentage of incorrect responses to each distractor showed that students with more non-religious (NR) than religious backgrounds (R) had different misconceptions about different aspects of astronomy. The findings wre listed as follows:

1. Students with NR backgrounds had a higher percentage of wrong distractors than students with R backgrounds, that is, 34.5% compared with 16.6% (noted as 34.5%-16.6%) in item 1; 20.7%-13.1% in item 3; 20.7%-6.2% in item 4. This shows that

more NR backgrounds students had misconceptions about lunar phases and the position related the time as well as about the reasons of lunar phases.

2. More NR (44.8 %-20.7%) students had the misconception that lunar phases are due to the earth's shadow. Also more NR (27.6%- 11.7%) students believed that the earth had no phase change because the earth is not covered by the sun's shadow. Further, More NR students (37.9%-17.2%) could not concepturlize the bird's-eye view.

3. More students with R backgrounds (56%- 48.3%) held the misconception that the earth's phases were due to the area of the earth reflecting the sun light changing. More R students (30.3%-17.2%) thought the position of the moon would move farther to the west on the next day at the same time. In addition, more R students (26.6%-13.8%) believed that the lunar eclipse occured on the new moon night.

Educational Major:

The science education-majors had too samll sample size to include the result of t-test. However, from the samples available in this study, the percentage of incorrect responses to each distractor showed that students with science education and non-science education major had even deversity on different aspects of misconcepts about the moon.

1. More science education-majors (SE) than non-science education-majors (NSE) (34.6%-14.9%) thought that the full moon was bright every where, that the new moon was bright no where,

and quarter moon was half bright. More SE majors (42.3%-29.1%) could not predict the position of the moon on the previous day. Also more SE majors (38.5%-15.5%) held the misconception that the earth's phases were caused by the changing of amount reflected sun light. Lastly, more SE majors (57.7%-29.7%) believed that an apple will float in the air if it were dropped on the moon.

2. More NSE majors (46.2%-33.8%) could not associate a lunar phase with the result of ball-shaped sun reflecting (see Fugyre 5). In addition, more NSE majors (29.7%-0%) could not draw either lunar or earth phases from a spaceman's view. More NSE majors (26.9%-18.2%) also held the misconception that are beaches located along the same latitude have the same high tide.

Discussion and Suggestions

Preservice elementary teachers will be required to teach the lunar concepts tested in this study, yet the results indicate that the preservice teacher in Taiwan holds many misconceptions related the moon. Although the Chinese people often view the moon at night as part of many activities, such as, a farmer predicting the lunar date by observing the lunar phase, a person worshiping Heaven on the days with a new moon and full moon, and people participating in festival celebrations on full moon nights, these preservice teachers still can not accurately predict the day of a lunar phase. The teachers confound how the lunar phase changes day by day. For example, when asked, to draw the lunar phase of the 13th day and a shape of partial lunar

eclipse, they would draw shapes in same. This reveals that they do not perceive the cause of two cases are different.(see Figure 5) A ball reflecting light or covered by another's ball-shape object will result different phases.

The preservice teachers held these misconceptions might due to their cognitive stage or the inadequate way of previous learning. Adults may stay at concrete operational cognitive stage when they confront a abstract concept or a bird's-eye view learning. Cognitive requirements for conceptual change were described in research papers (Hewson, 1981; Posner, et al, 1982). In addition, when students previously learned about the moon, they might not learn concept rather they learned the factual knowledge or superficial understanding (Crawley & Arditzoglou, 1989). Consequently, they soon forget the concepts learned from classroom.

The effective teaching strategy for instructing Astronomy or Earth Science for these particular concepts learning in teacher training program suggested here is demonstrating the model of the sun-earth-moon or the usage of valley ball and bulb light. By doing so to meet proper cognitive stage, the students observe the phenomena which is difficulty to verbally describe. Once the preservice teacher had learned the operational activities of model demonstration from the science method course and Earth Science, we believe that the misconception of lunar phase, the cause of lunar, and position association with moonrise will be deleted.

The preservice teachers have high percentage on misconceptions regarding to the moon's rotation and revolution. The objects in the heaven involve their rotation and revolution in solar system which is complex. The earth spins as it rotates while the moon rotates as it revolves. (see Figure 4) The students who learn this complex phenomena by merely reading descriptive text or lecture do not construct concepts in their mind. Brumby (1984) concluded that lectures are insufficient for learning science concepts. Unfortunately, lecture teaching method is most adopted at college level teaching.

Another effective teaching strategy for instructing science method course and Earth Science in teacher training program suggested here is role playing. The rationale for use of role playing in this particular concept learning is that when students simulate the movement of heavenly objects and planets, role playing brings them back to operational cognitive stage to learn. They will discover how the moon rotates while it revolves, how the lunar phase changes when the actors view the earth and the moon each other toward different angles which cause the changes of the lunar phase.

The effective instruction models bring a conceptual change has been evidenced in research (Stepans, Dyche & Beiswenger, 1988; Reif, 1987; Idan & Ganiel, 1985). Further research can be conducted employing the teaching strategies suggested above to change concepts. Since the findings of religion groups show that more non-religion-backgrounds had misconceptions of lunar phase

and the position associating the time and on the reasons of lunar phases, another further research can be conducted how the religious activities effect religion-background' conceptions. The scores of gender subgroups show that no significant difference. This result differs from Schoon (1989) and Za'rour's (1975) findings which showed that males hold fewer misconceptions in science than did female. Their studied subjects were drawn from different levels and backgrounds rather than focussing on preservice teacher.

This study has addressed that teacher training program in teacher college should provide strong background on science content for preservice teacher. We hope that Astronomy be offered in teacher college program in Taiwan.

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